# COMPENSATING DISK TENSION CONTROLLER

This invention relates to an apparatus and method for controlling the tension in moving yarns. More specifically, it compensates for varying tension over the time of a process and results in consistent strand tension, which is often desirable for the next downstream process.

Numerous types of tension devices are known for the purpose of increasing the tension in a travelling strand. These include mostly devices which add tension to the traveling yarn. Some of them apply pressure to the traveling yarn, which in turn adds tension, based on the product of applied force times the friction coefficient. Others deflect the traveling strand around one or several posts and through these deflections increase the tension depending on the bending angle and the friction coefficient between the traveling strand and the bending surface.

More sophisticated strand tensioning systems use complex and expensive electronic means to measure the strand tension and electronically vary the applied tension with a close-loop feedback to achieve constant output tension. Their high cost prohibits their application for most, but extremely sensitive applications.

The invention disclosed in this application employs a tension device consisting of two friction plates between which the strand travels. It achieves constant output tension by reducing the applied tension between these two friction plates by the same value as the amount of upstream tension of the yarn. Since the total downstream tension is the sum of the tension upstream of the tension device and the tension added by the tension device, the downstream tension in the disclosed invention is constant.

In accordance with a first aspect of the present invention there is provided a strand tension apparatus, comprising:

(a) a strand delivery mechanism for delivering a moving strand (3) downstream from a strand supply (2);

(b) a strand take-up mechanism (7) positioned downstream from the strand delivery mechanism for pulling the strand (5) from the strand supply;

(c) a tension controller (1) positioned between the strand delivery mechanism and the strand take-up mechanism for adding tension to the moving strand as it moves downstream to the strand take-up mechanism, the tension controller including a pair of tensioning plates consisting of a stationary tensioning plate (9) and a second, movable tensioning plate (10), between which plates the moving strand passes; and

(d) an adjustable loading force applied to the movable tensioning plate in opposite direction to the movement of the strand generating through geometric restriction a force component perpendicular to the direction of the moving strand perpendicular to the direction of the moving strand in the region of the tensioning plates; and

(e) means to deflect the upstream strand entering the tension controller, generating in the tension controller a deflection force of which a force vector is directed in opposite direction of the adjustable loading force for a reduction of the added tension to the strand.

For further details of how we define the apparatus in terms of protective scope the reader is now referred to claims 2-11 hereafter.

In a preferred method of this invention, a wedge is pushed between a fixed cam-surface and one of the two friction plates which in turn pinches the moving strand with the second, fixed friction plate. The moving strand is deflected around the movable friction disk and its upstream tension opposes the pushing force of the wedge, hence reducing the compression force on the moving strand. A constant output tension is achieved by selecting the proper ramp angle for this wedge.

Preferably there is provided a strand tension controller for maintaining substantially uniform strand tension for delivery to a downstream strand processing station.

Preferably there is provided a strand tension controller which allows to set a desired tension level and tension uniformity downstream from the strand tension controller.

Preferably there is provided a strand tension controller which includes means for uniformly and simultaneously setting the strand tension on a plurality of yarns being processed.

Preferably there is provided a multiple set of strand tension controllers for which the desired tension level in all yarns can be changed simultaneously to fit a specific need in a downstream strand processing station.

Preferably there is provided a multiple set of strand tension controllers for which the desired tension level in all yarns can be changed simultaneously. Preferably the arrangement is such that each unit can be fine-adjusted individually to make it suited for specific needs in a downstream strand processing station.

These and other features of the present invention can be achieved, wholly or in part, by providing a strand tension controller with provision for reducing a compression force of the tension controller to the strand to achieve a desired tension. If the incoming strand has no tension, the full compression force is applied by the tension controller to the yarn. If the incoming strand has tension, the compression force is accordingly reduced.

The compression force may be provided to the tension device by mechanical means.

The compression force may be provided to the tension device by fluidic means.

The compression force may be provided to the tension device by electrical means.

The compression force may be provided to the tension device by means of permanent magnets.

In the preferred embodiments disclosed below there is provided a mechanical strand tension controller, comprising a strand guiding entrance which partially deflects the incoming strand around the movable tensioning plate and guides the strand between a stationary tensioning plate and a movable tensioning plate, a force applying spring, a wedge between the movable tensioning plate and a stationary cam surface and a strand exiting guide. The spring pushes the wedge between the fixed cam surface and the movable tensioning plate and exerts a compression force on the traveling strand between the two tensioning plates. The compression force of the spring may be partially relieved through the resulting deflection force of the incoming strand to achieve a substantially constant output tension in the downstream strand.

Preferably the invention uses common tension-disks, as used in most tension devices.

The invention will now be further described, by way of example, in the accompanying drawings, in which:

FIG. I is a perspective view of the tension controller according to one embodiment of the invention;

FIG. **2** is an overall perspective view of the tension controller with a view of the path of the strand from the supply to the take-up according to an embodiment of the invention;

FIG. **3** is a side view of the tension controller with the strand exiting to the left;

FIG. **4** is a top view of the tension controller with the top part removed to show the inside of the tension controller;

FIG. **5** is an exploded view of the tension controller with all parts shown. Center lines connect the individual parts to facilitate the understanding of how the parts fit together;

FIG. **6** is a simplified cross-sectional view of the tension controller with the inserted strand and the adjustable loading force applied to a wedge;

FIG. **7** is a force diagram with zero upstream tension and shows how the loading force is generating the compression acting on the tensioning plates;

FIG. **8** is a force diagram with nominal upstream tension and shows how the loading force is reduced by the upstream tension;

FIG. **9** is a sectional front view of the tension controller with central setting of the loading force through an air tube;

FIG. **10** is a sectional front view of the tension controller with central setting of the loading force through electro-magnetic force;

FIG. **11** is a sectional front view of the tension controller with the setting of the loading force through a permanent magnet;

FIG. **12** is an alternate method with the wedge of Fig. 6 being replaced by linkages, achieving similar force characteristics;

FIG. **13** is a perspective view of the tension controller according to one embodiment of the invention with a floating guide touching the tensioning plate;

FIG. **14** shows the forces and angles thereof reacting on the tension controller;

FIG. **15** shows how the tension controllers can be centrally controlled by a common electrical supply.

Referring now specifically to the drawings, a tension controller **1** is broadly illustrated in FIG. **1** as a part of a strand tension apparatus, including a strand supply and take-up mechanism. A supply package **2** dispenses of the upstream strand **3** which enters into the tension controller **1** through an entrance guide **4**. The downstream strand **5** exits the tension controller **1** through the exit guide **6** to be wound up by the take-up package **7**.

Referring now to FIG. **2**, a perspective view shows the tension controller **1** having a bracket **8**, shown transparent for clarity. A stationary disk **9** is shown, located below a movable disk **10**. A wedge plate **11** is locked in place inside the movable disk **10**. A setting spring **12** is held on one side by a set-screw **13** which is inserted in a bore in the bracket **8**. The other side of the setting spring **12** pushes against the wedge plate **11**. Two balls **14** are located between a wedge slot **15** in the wedge plate **11** on one side and in a bracket slot **16** in the bracket **8** in order to reduce the friction between the fixed bracket **8** and the sliding wedge plate **11**, which in turn is fastened to the movable disk **10**.

In FIG. **3** the same parts are shown in front view. Especially noteworthy is the wedge angle **23**, which plays an important role in the function of the tension controller.

Referring now to FIG. **4**, a top-section of the tension controller **1** is shown with the top part of the bracket **8** removed.

FIG. **5** is an exploded view of the tension controller **1** with all parts shown. Center lines connect the individual parts to facilitate the understanding of how the parts fit together. It also shows the self-adjusting mounting of the stationary disk **9** which fits with its center hole **18** onto the bracket horn **17** of the bracket **8**. This assures an even contact between the two contact surfaces **19** of the stationary disk **9** and the movable disk **10**.

Referring to FIG. **6**, a schematic drawing of the tension controller shows the tension wedge **21** symbolizing the wedge plate **11** (not shown). The shaded surfaces **22** are stationary surfaces. The adjustable loading force **20** is acting on the tension wedge **21** which has a wedge angle **23**. The upstream strand **3** is bent around the movable disk **10** and is compressed between the movable disk **10** and the stationary disk **9** and the downstream strand **5** proceeds to the take-up package **7** (not shown).

The schematic drawing FIG. **7** of the tension controller **1** together with a force diagram **29** demonstrates how the adjustable loading force **20** is acting on the tension wedge **21**. The loading force **20** is broken down into the two force components, a normal force **24** and a compression force **26**. The normal force **24** is taken up by the stationary surface **22** and has no effect on the strand **25**. The compression force **26** acts on the strand **25** by compressing it between the movable disk **10** and the stationary disk **9**. It should be noted that the force angle **27** is equal to the difference between **90°** and the wedge angle **23**. The symbol **28** denotes a right angle of **90°**. It is assumed in this drawing that the upstream strand **3** has zero tension.

Referring to FIG. **8** the same adjustable loading force **20** is acting on the tension wedge **21**. In addition it shows the up-stream tension **30** in the upstream strand **3** with its resulting strand tension **31**. It should be realized that the value of the strand tension **31** is larger than the value of the up-stream tension **30** due to the frictional forces added during the passing of the strand **5** around the movable disk **10**. The force reduction **32** demonstrates how the adjustable loading force **20** is reduced by the value of the strand tension **31**. The resultant force diagram **33** shows the reduced loading force **34** with a reduced normal force **35** and a reduced compression force **36** as compared to FIG. **7**, which will add less tension to the strand **5**. It may be noted that the relative small influence of the up-stream tension **30** on the resultant force diagram **33** has been disregarded for reason of simplification.

Referring now to FIG. **9**, the wedge plate**11** is loaded by an air pressure system. A U-channel **37** contains an elastic air tube **38**. It pushes over the pressure anvil **39** through a pressure stem **40** with a ball enlargement **41** against a hole **45** in the wedge plate **11**. The pressure anvil **39** is provided with a tap **43** and the pressure stem **40** has a thread **42** which is threaded into the tap **43**. An adjustment wheel **44** on the pressure stem **40** allows fine adjustment of the adjustable loading force **20** of each individual tension controller **1**. By changing the air pressure in the elastic air tube **38** the adjustable loading force **20** (not shown) on a number of individual tension controller **1**, connected to the same air system can be varied simultaneously.

Referring now to FIG. **10**, the wedge plate **11** is loaded by electromagnetic force. An electromagnet spool **46** is mounted on the bracket **8**. An anvil disk **47**, with a disk tap **48**, transmits the force through the magnet stem **49**, with a stem ball **50**, against the hole **45** in the wedge plate **11**. Each tension controller **1** can be individually adjusted by turning the anvil disk **47** against the magnet stem **49**. Changing the voltage of the electrical supply to

the electromagnet spool **46** a number of individual tension controller **1**, connected to the same electrical system, can be varied simultaneously.

Referring now to FIG. **11**, the wedge plate **11** is loaded by a permanent magnet **51**. The permanent magnet **51** is mounted on the bracket **8**. An anvil disk **47**, with a disk tap **48**, transmits its force through the magnet stem **49**, with a stem ball **50**, against the hole **45** in the wedge plate **11**. The tension controller **1** can be adjusted by turning the anvil disk **47** against the magnet stem **49**.

The tension controller **1** in FIG. **12** achieves the same force characteristics as shown in FIG. **6** to **8** with pivotal levers **52**. Each pivotal lever **52** is pivotally mounted on the stationary surface **22** on one side and on the movable disk **10** on the other side. The same force diagram **29** applies to this system.

Referring to FIG. **13**, a floating guide **53** is pushing against the movable disk **10** in order to treat the strand **3** more gently. The disk lever **54** with the floating guide **53** is pivotally mounted on the bracket **8** by the pivot **55**.

FIG. **14** shows the forces as they apply to the tension controller **1**. For this tension analysis the tension controller **1** is shown with the floating guide **53** as shown in FIG. **13**. The upstream strand **3** is guided around the floating guide and the strand **26** is compressed between the stationary disk **9** and the movable disk **10**. The adjustable loading force **20** is applied to the tension wedge **21**. By selecting the proper wedge angle "$\alpha$" for each input angle "$\beta$" the tension controller "1" becomes fully compensating for constant output tension **58**. It is believed that the following formula is applicable:

$$\tan \alpha = -\mu + 2\,\mu(e^{\mu\beta} - \cos\beta)\,/\,(e^{\mu\beta} - 1)$$

It is understood that "$\mu$" is the friction coefficient between the strand **26** and all surfaces it contacts. It is also understood that if "$\mu$" is not constant, the formula for "tan $\alpha$" has to be modified correspondingly.

With respect to FIG. **15,** several tension controllers **1** are shown where the electromagnetic spool **46** of each tension controller **1** is connected to a central wiring **59** by means of the branch wiring **60**. By changing the voltage in the central wiring, all tension controllers **1** can be set simultaneously.